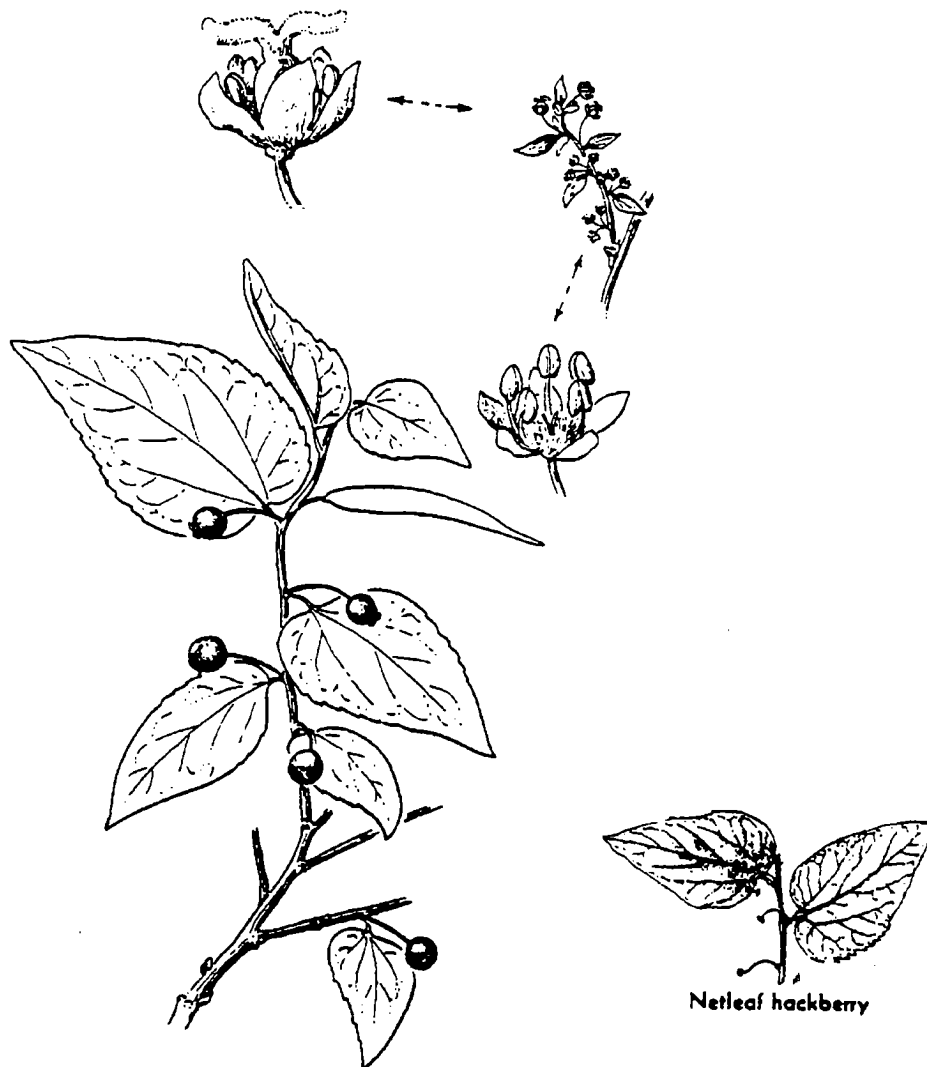

IS THE NETLEAF HACKBERRY A VIABLE REHABILITATION SPECIES FOR IDAHO RANGELANDS?

by
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NETLEAF HACKBERRY

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ABSTRACT

Netleaf hackberry's (Celtis reticulata) fragmented distribution in Idaho appears to be controlled by a variety of factors. Hackberry is generally restricted to semi-arid portions of the state where temperatures are least severe during the winter months, such as in moderated river canyons and at elevations below 1,500 m. Hackberry occurs in a variety of habitats, however, it is most abundant on sites with a southeast to southwesterly aspect and a rocky surface cover.

Although seeds have low germination rates and individuals are often slow-growing, the variable site conditions which hackberry tolerates, in addition to its other positive attributes (i.e. landscape structure, wildlife food and cover, resprouting potential), are favorable qualities for rehabilitation species. While experimental study plots are needed to test the species' ultimate suitability for rangeland rehabilitation in Idaho, some general planting recommendations can be made based on the results of this research combined with field observations.

INTRODUCTION

Netleaf hackberry (*Celtis reticulata*), hereafter referred to as hackberry, is an irregularly shaped deciduous shrub or small tree in the elm family (Ulmaceae) with a wide but fragmented distribution. It occurs in semiarid regions of the western United States, in portions of the Great Basin, western Great Plains, Pacific Northwest, and southwestern United States (Lanner 1983; Little 1976; Stephens 1973) (fig. 1). However, its distribution becomes especially fragmented near its northern limit in Idaho, Oregon, and Washington.

Hackberry occurs in a variety of habitats, including mountain shrub, deciduous riparian woodlands, and live oak-mixed shrub communities, in rocky canyons, and as scattered individuals in semi-desert grasslands, Joshua tree and pinyon-juniper woodlands (Albee and others 1988; Glinski 1977; Plummer 1977). Populations are often small and highly localized (Daubenmire 1970; Dooley and Collins 1984), particularly near its northern limit (Eliot 1938). Little is known about its ecology, presumably due to its position as a minor component in many of its habitats and its fragmented distribution (Lanner 1983).

Hackberry is sparsely distributed in Idaho (fig. 2), but it exhibits wide ecological tolerances. It is a member of both riparian and upland communities between 250 m and 1,500 m, where it can be a locally abundant, overstory dominant (Huschle 1975; Johnson and Simon 1987). Along the Wiley Reach of the middle Snake River, it forms narrow but extensive gallery forests of nearly pure hackberry (Bowler 1981). On steep shoreline escarpments of the lower reaches of the Snake River, hackberry is characterized by a dense, nearly closed canopy (Huschle 1975). Where it grows on the gentle shoreline slopes, alluvial fans, and colluvial cones of the lower Snake River, it forms an open savanna (Daubenmire 1970; Huschle 1975).

Hackberry produces a fleshy, orange-red drupe containing a single seed. Fruits ripen in late fall and are dispersed by birds, rodents and other small mammals, and gravity (Dayton 1931; Lanner

Figure 1—Global distribution of netleaf hackberry.

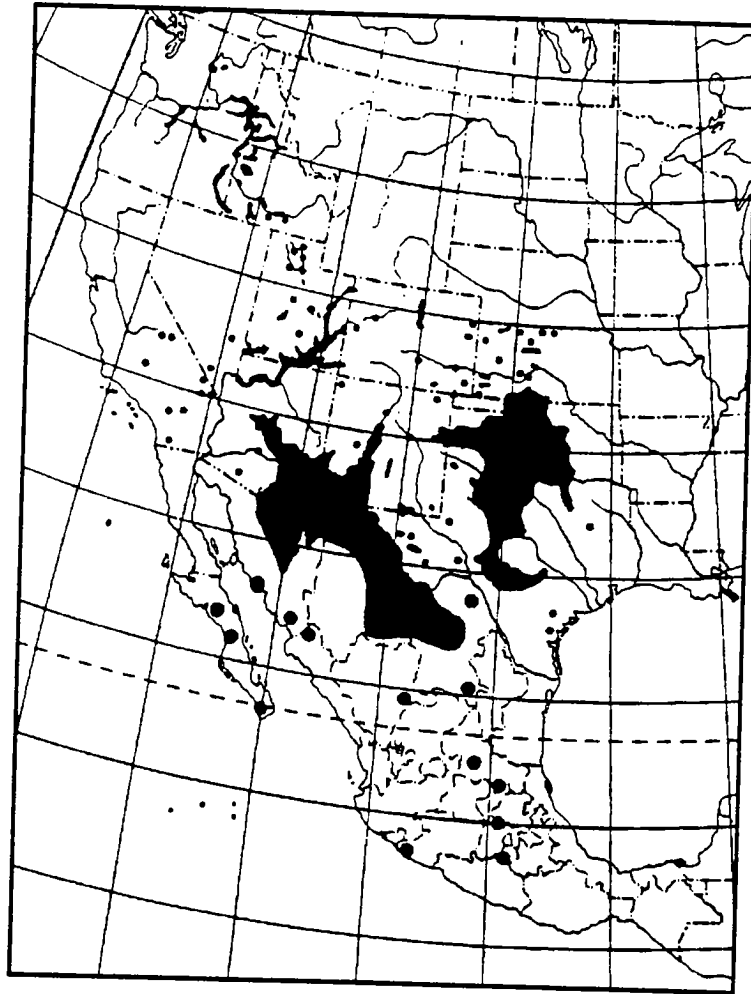
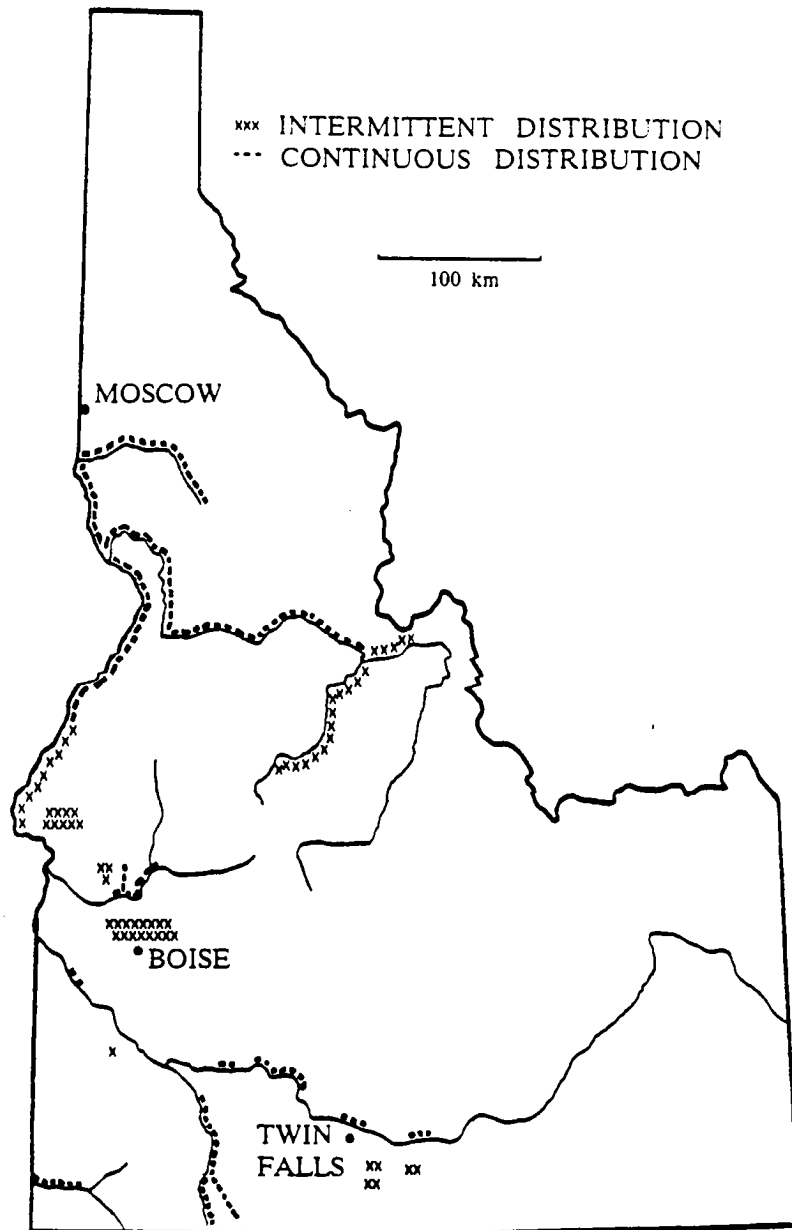


Figure 2---Distribution of netleaf hackberry in Idaho.



1983; Martin and others 1951). Leaves and twigs are browsed by a variety of wildlife, including bighorn sheep (R. Rosentreter 1990), elk, mule deer, and wild turkey (C. A. Johnson 1990), in addition to domestic livestock (cattle, sheep, horses). Following the removal of aboveground portions by herbivory or other disturbance, plants readily resprout from the root crown or stem base (Carter 1964). Hackberry also commonly resprouts after fire (Armstrong 1980; Carmichael and others 1978; DeBolt 1992).

In addition to food, hackberry provides cover and nesting habitat for wildlife and game species, often on sites where other shrub or tree species are scarce or absent. In the Snake River canyon, Asherin and Claar (1976) documented the importance of hackberry communities for at least 41 species of birds.

Hackberry can persist in the presence of many anthropogenic perturbations and natural disturbances, and it is sometimes the only woody species of any height remaining on degraded rangelands (Daubenmire 1970; Johnson and Simon 1987). Due to hackberry's apparent tolerance of harsh growing conditions, its potential to resprout following disturbance, and its wildlife values, using this species to enhance disturbed habitats is of interest to public land managers. However, little research in this area has been done to date. This study sought to gain some basic knowledge on hackberry growth rates, longevity, and ecological tolerances to evaluate the species' utilization potential for rehabilitation projects in Idaho. This knowledge, in addition to field observations, can help us begin to formulate guidelines for planting netleaf hackberry in Idaho.

METHODS

Two hundred forty-one hackberry stands spread over much of the species' range in Idaho, and adjacent Oregon and Washington were sampled ($N = 241$). Stands were selected based on within-site homogeneity of apparent history, topography, and parent material, and a minimum population size of

six hackberry individuals (many more individuals were usually present). Sampling areas were typically irregularly shaped and small, usually less than 0.25 ha.

Stands were assigned to the following topographic positions or physiographic classes: river/stream terrace, high water line, rocky draw, bench, toe slope, lower slope, broken lower slope, mid slope, upper slope, talus, and draw. Stand-level data recorded in addition to topographic position included: elevation; latitude; longitude; aspect (converted to a heat load index with values ranging from 0 [NE slopes] to 1 [SW slopes]); slope; percent surface rock cover; parent material; surface soil texture; an assessment of total stand density; an assessment of density within four reproductive classes, including seedling, juvenile, mature, and decadent individuals; topographic shelter; number of cohort modes; grazing intensity; and associated dominant plant species.

Within each stand, a minimum of three individuals, chosen to represent the modal size in the stand, were sampled ($N = 939$). The modal size is defined as the typical size of individuals in the dominant (most abundant) cohort. Measurements recorded for each tree included height, age, diameter at core height (typically 20 cm above ground level), number of live and dead stems, and percent rock cover below the canopy as centered over the main trunk. When two or three modal sizes were present, all modes were sampled, for a minimum total of either six or nine individuals. When stands were all-aged with no apparent modal tree size, at least six individuals of the dominant canopy cohort were sampled. The number of modes present, from 1 to 4, with 4 equivalent to an all-aged stand, was recorded as a stand-level variable. Sampling methodology was identical in overgrazed stands for all variables, although a greater number of trees were typically sampled.

To compare hackberry growth rate differences under various environmental conditions, a 50-year site index was developed as a measure of growth potential (i.e. site quality), as outlined in Husch and others (1972). Site index is the most widely used method of evaluating site quality for tree growth (Daubenmire 1976; Husch and others 1972). Utilizing regression analysis, the relationship of tree height to age formed the basis for the index (DeBolt 1992).

A separate stand-level data set was constructed from stand-level variables and averages of tree-level variables. Thus, site index values were averaged for each stand to obtain one variable as the single numerical expression of site quality for a given stand. The original tree level variables were also averaged and included in this data set.

Statistical techniques included one-way analysis of variance (ANOVA), simple linear regression, cross tabulation, and analysis of covariance. All differences were accepted as statistically significant at $p \leq 0.05$, unless otherwise noted.

RESULTS AND DISCUSSION

Fifty-year old hackberry trees in Idaho averaged 3.9 m tall, while the mean height of dominant and codominant hackberry, regardless of age, was 4.9 m. Site quality, as expressed by the height-based site index, differed among the eleven topographic positions identified ($p = 0.0001$, $F = 4.4$). However, variation within topographic positions was large so that only draws differed from any other specific topographic position. A general pattern of faster growth where plants were in sheltered and mesic habitats to slower growth on more xeric and exposed sites was identified (i.e. highest site index values in draws, lowest values on talus slopes).

An examination of 241 stands and 939 individual trees demonstrated that hackberry is most prevalent on southeast- to westerly aspects. Twenty-five percent (60) of the stands were found on SW slopes, with a heat load between 0.95 and 1.00, the hottest values of the heatload index. Only 32 stands (13 percent) were located on the coolest sites between 0.00 and 0.20, or between 350° and 98° east of north. The mean heat load index was 0.69. However, aspect was not a good predictor of growth rate, as topographic features appeared to override the influence of aspect, creating growing conditions that are probably not as harsh as they first appear. Under arid and semi-arid conditions, local topography becomes of considerable importance for plant growth, as even the slightest

depression can collect run-off and lower temperatures (Heth 1981). Of 241 hackberry stands, 168 (70 percent) had an intermediate or better topographic shelter, although variability within each class of shelter was large ($r^2 = 0.13$).

While hackberry occurs in a variety of habitats, the ground surface is nearly always rocky ($\bar{x} = 39$ percent). Field observations suggest that sites may be even rockier below the surface, with rock possibly serving as a reservoir of subterranean moisture. The presence of rock, particularly bedrock, may in fact be critical for hackberry's existence on certain sites, and at least partially explains its fragmented distribution in Idaho. Other rock-associated species have been observed in semi-arid regions as well.

In the shrub-steppe region of eastern Montana, Rumble (1987) found that scoria rock outcrops provided a unique habitat for several relatively mesic species. Skunkbush sumac (*Rhus trilobata*), chokecherry (*Prunus virginiana*), currant (*Ribes* spp.), and juniper (*Juniperus* spp.) were found only in association with rock outcrops in that ecosystem. He concluded that their occurrence was probably related to protection from wind, snow drift accumulation, shading, and the mulch effects of the rocks. Oppenheimer (1964) and Potter and Green (1964) suggested that the association of mesic species with rocky substrates was due to the temporary water reservoirs that rock fissures provide. In Arizona, Johnsen (1962) reported that one-seed juniper (*Juniperus monosperma*) was largely limited to rock outcrops, where he recorded 2-2.5 times as much available moisture. The theory of extra moisture availability in rock fissures could also hold true for the deeply rooted hackberry, helping explain its frequent presence on southerly aspects. Although rock may be important for recruitment, trees show a weak tendency to grow more slowly with a higher surface rock cover ($r^2 = -0.28$, $p = 0.0001$).

In Idaho, hackberry is typically slow-growing and long-lived (to 374 years, $\bar{x} = 66$ years). Trees grow best where maximum topographic shelter is present, such as in draws, and where soils are loamy ($p = 0.017$), although variability was high among soil and shelter classes. Site potential was higher on the finer textured soils (clay or loam) than on coarse textured soils (sand), probably because

of their greater water holding capacity and nutrient content (Brady 1974). However, 80 percent of the stands occurred on soils with some sand component, and 30 percent were on sand or coarse sand. The presence of good drainage may be an important limiting factor for hackberry, as the finer textured soils of the uplands were nearly always skeletal.

Hackberry grows on a variety of parent materials in Idaho, including sandstone, granite, alluvium, and basalt. Although no growth rate differences were found among parent materials ($p = 0.43$), individuals growing on sandstone were often shrubbier (greater number of stems) than those on other substrates. The multiple stems probably result not so much from the sandstone but from anthropogenic and geographical factors confounded with sandstone. All sandstone-associated stands were near Boise, where fire frequencies are higher. This resulted in more live and dead stems per individual. Sandstone sites were typically dry uplands away from perennial water sources and draws that act as natural fire breaks.

Few newly established hackberry stands were observed during the study. Within these stands, surface cover was typically rocky, suggesting that rock may provide "safe sites" for establishment. Despite the fact that only six new stands were recorded, populations seem to be maintaining themselves, with juveniles present in the majority of stands. Stands under heavy livestock grazing pressure may be an exception, however, as recruitment was often lower and a single cohort was dominant (Chi-square, $p = 0.0008$) (table 1). Of 239 stands, 36 (15 percent) were on sites classified as severely overgrazed. Overgrazed sites lacked all-aged stands, tending almost completely towards demographic unimodality (92 percent). In contrast, 70 percent of the light to moderately grazed stands had only one mode, 11 percent were bimodal, and 18 percent were all-aged.

Hackberry has a remarkable combination of life history characteristics that make it a promising species for rehabilitation of damaged sites. It is resilient to fire and resistant to grazing pressure once established. While hackberry does not readily colonize new sites, it is quite persistent on the sites where it does occur. This suggests that plantings, with several years of protection, have a

Table 1---Cross tabulation of the number of hackberry stands by the number of modes and grazing intensity. The hypothesis of independence of mode number and grazing intensity is rejected with $p = 0.0008$.

	Modes			Row total
	1 mode	2 modes	All-aged	Row percent
Grazing intensity				
Low to moderate				
observed	143	23	37	203
expected	149.5	22.1	31.4	85
Severe				
observed	33	3	0	36
expected	26.5	3.9	5.6	15
Column total	176	26	37	239
Column percent	74	11	15	100

high probability of long-term persistence. The wide range of conditions in which hackberry is found imply that rehabilitation will be successful in many different habitats, however an evaluation of outplanted seedlings across site conditions is needed.

The potential longevity of hackberry, its fruit production for wildlife, tolerance of sites that appear harsh, and the structure and cover it provides, are positive qualities for a rehabilitation species in arid landscapes. Until additional studies are conducted, the planting recommendations that follow will provide some guidance for interested land managers.

RECOMMENDATIONS

1. Because of hackberry's low germination rate and generally slow growth rate, introducing the species to a site is best accomplished with seedlings rather than by direct seeding. An optimum size or age for container seedlings has not been determined, but one full year of growth is probably a minimum.
2. Seedlings should be grown from local seed sources, as the range of adaptability for most hackberry populations is unknown.
3. Seed should be subjected to a cold stratification (with pulp retained) treatment to increase percent germination. Seed less than two years old is probably preferable, as viability declines with age (Bonner 1974).
4. Plant seedlings in the spring on sites with a high percent of surface rock cover (> 25 percent), adjacent to or within portions of rock outcrops with soil, and place rocks around newly planted seedlings. This will increase moisture availability to seedlings and reduce competition with adjacent vegetation. Rock or gravel mulches have been used successfully in Montana (Richardson 1977) and Arizona (Heidman and others 1977) to establish shrub and conifer seedlings.

5. Seedlings should be planted on well-drained soils with an east, south, or west aspect.
6. Seedlings should be planted where surface rock or the surrounding topography provide some shelter from the environment (i.e. draws, stabilized gullies, rock outcrops).
7. Seedlings can be planted adjacent to perennial water, but they should be above the zone of extended root saturation.
8. Create small water catchment basins around each seedling when planting. This will capture and provide extra moisture to the seedling.
9. For nursery-grown seedlings, inoculation of soil with local mycorrhizal fungi and other soil microorganisms should be considered.
10. Seedlings and young juveniles are often eaten by rodents, rabbits, and probably livestock. Protecting seedlings from herbivores with mesh "cages" or other such structures should increase the survival rate of hackberry seedlings.

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